Saskatchewan
Agriculture, Food
and Rural
Revitalization

ADF

AGRICULTURE DEVELOPMENT FUND

FINAL REPORT

19980043

ASSOCIATION OF FUSARIUM SPP. AS ROOT ROT PATHOGENS WITH FUSARIUM HEAD BLIGHT IN SASKATCHEWAN

Funded by:
The Agriculture Development Fund

March 2003
Prepared by: Agriculture and Agri-Food Canada

103-04741/

Association of Fusarium spp. as root rot pathogens with Fusarium head blight in Saskatchewan

Agriculture Development Fund #98000043

FINAL REPORT

July 2002

by Myriam R. Fernandez and Penny Pearse

Executive summary

Fusarium head blight (FHB) has become an important disease in eastern Saskatchewan in the last few years and is also present at low levels in the rest of the province. FHB started causing serious damage in Manitoba in the mid-80's and has since spread westward. This disease reduces grain yield and quality of cereal crops and it thus has significant economic impact on producers. Quality losses are due to a mycotoxin produced by the *Fusarium* infections which are harmful to humans and animals.

The same *Fusarium* spp. that infect heads also infect roots and crowns of plants. Root/crown infections could be due to pathogens present in crop debris or infected seed. It is possible that this disease was introduced into Saskatchewan through the planting of infected seed, which led to root infections.

This project represents the first comprehensive study of root and crown rot pathogens in Saskatchewan. The objective was to identify the presence and importance of each of the different *Fusarium* spp., their distribution in different soil types, and whether or not the same isolates derived from roots could also cause FHB. This is an important step in trying to understand the spread and dispersal of these pathogens.

A province-wide survey showed that the same species isolated from heads could also be isolated from roots, although at different frequencies. The fact that *F. graminearum*, the most important FHB pathogen, was only isolated from roots/crowns in FHB-affected areas of SK suggests that crop debris from infected plants or infected seed may be sources of inoculum of *F. graminearum* for infection of underground plant parts.

The observation that the same *Fusarium* spp. responsible for FHB in SK were isolated from roots of cereal and noncereal crops grown in rotation with wheat led to the question of whether these same isolates were adapted to different plant parts or crops, and whether they had similar relative pathogenicity on wheat heads and roots/crowns. Pathogenicity tests were then designed to determine: (1) whether isolates of *Fusarium* spp. had the same relative pathogenicity on heads and on underground plant parts; and (2) whether isolates from different sources (cereal and noncereal crops) had the same pathogenicity. In most cases, different isolates from heads or from crowns/roots had the same relative pathogenicity on different plant parts, and there appeared to be a lack of adaptation of isolates to different plant parts or crops.

These observations suggest that inoculum from debris from plant parts at or below soil level might be a source of inoculum for infection of heads, and/or that infected heads/kernels might be contributing to root infections. It was also shown that perithecia, the fungal reproductive structures, could form on infected seedlings, suggesting that infected plants could be a source of inoculum for head infections the same season, as well as in future years as previously suggested.

The observation that there were no differences in pathogenicity among isolates from different crops led to the conclusion that alternative crops could act as hosts for *Fusarium* spp., which could then infect heads or roots of subsequently grown cereal crops and thus be part of the disease cycle. This is the first time that it has been suggested that rotations with alternative crops could affect the development of FHB and root rot/seedling blight of wheat in SK.

The results from this study formed the basis of recommendations that producers should avoid introducing *Fusarium* inoculum through infected seed into areas of the province not yet affected by FHB. These recommendations are a proactive approach as they are aimed at stopping the spread of FHB in the western Prairies. The results of this study help our understanding of the spread of FHB and are thus of great benefit to producers and the cereal industry.

Background

Fusarium head blight (FHB) is a serious disease of cereal crops and has the potential to cause significant losses to producers and health effects to humans and animals. Fusarium-damaged kernels (FDK) cause reduction in grain yield and quality due to downgrading. Tolerance levels for FDK are very low due to the harmful effects of mycotoxins produced by *Fusarium* infections.

The most important *Fusarium* sp. associated with FHB in areas where this disease is well established is *F. graminearum* (formerly known as *F. graminearum* Group II). This species produces the mycotoxin DON in infected grain. Other species, such as *F. avenaceum*, are important in SK (Fernandez et al., 2000; 2001a). In the last few years, *F. graminearum* has moved westward from Manitoba. Province-wide surveys indicate that FHB is present at high enough levels in eastern SK to cause downgrading (Randy Clear, personal communication).

It is not known how *F. graminearum* has spread westward, but speculation is that it has spread slowly by wind or by planting infected seed. The latter might explain the presence of *F. graminearum* found occasionally throughout areas of the province outside the southeast. Not much is known about the epidemiology of *F. graminearum* which could explain the apparent spread of this fungus westward. The same *Fusarium* spp. that cause FHB have also been associated with root rot of wheat (Wiese, 1987), and *F. graminearum* has also been isolated from infected roots (Windels and Holen, 1989). There has not been a comprehensive study of root rot pathogens throughout SK that could identify the presence and importance of each of the different *Fusarium* spp., their distribution in different soil types, and whether or not the *Fusarium* spp. isolated from infected roots could also cause FHB.

The objective of this study was to determine whether the most dominant *Fusarium* spp. causing FHB could also be found colonizing roots, and whether they have similar pathogenicity regardless of the source of the isolates. This would be an important step in trying to understand the spread and dispersal of these pathogens, and their distribution across the province.

Surveys

Crowns and roots of wheat and barley plants were collected by Saskatchewan Agriculture, Food and Rural Revitalization extension agrologists throughout the province in August of 1998 and 1999 (done through "Saskatchewan Cereal Disease Survey" ADF project). Samples were

sent to the Semiarid Prairie Agricultural Research Centre for processing. Samples were thoroughly washed free of soil and subcrown internodes and crowns/lower culms were rated for severity of discoloration. Discolored subcrown internodes and crowns/lower culms were surface sterilized and plated on nutrient agar (mPDA) for isolation and identification of pathogens.

Results and Discussion

Differences among fungi between years, between common and durum wheat and among soil zones were of a quantitative nature. There were more fungi that were widely distributed than fungi with high relative density. There is no province-wide study of root and crown rot previously done in Saskatchewan to which we could compare our results.

Many of the fungi isolated from subcrown internodes and crowns were saprophytes or weak pathogens, with the minority considered to be pathogens. The pathogen with the highest relative abundance (percentage isolation) and frequency (percentage of fields) was *Cochliobolus sativus*. *Fusarium* spp. were the second most common species. However, there were few *Fusarium* spp. isolated from subcrown internodes and crowns of common and durum wheat, and even fewer that were commonly isolated. Among them, *F. equiseti* was the most common and widely distributed, followed by *F. culmorum*, *F. avenaceum* and *F. acuminatum*. *Fusarium graminearum* and *F. pseudograminearum* (formerly known as *F. graminearum* Group I) were isolated at low frequencies.

The same species found in subcrown internodes and crowns were also found in heads with FHB symptoms (Fernandez et al., 1999; 2000a), although at different frequencies. For example, *F. poae* was a common fungus isolated from heads in SK but found only occasionally in roots and crowns in this study. Although no *F. pseudograminearum* was isolated from heads in SK (Fernandez, unreported observations), this pathogen has been isolated from grain of crops affected by head blight outside North America, which suggests that certain conditions might lead to infection of spikes by this fungus. *Fusarium graminearum*, the most important *Fusarium* sp. associated with FHB in North America, was only isolated from roots/crowns in FHB-affected areas of SK. This suggests that infected crop debris, or infected seed, may be sources of *F. graminearum* inoculum for infection of underground plant parts. This suggests roots/crowns can play a role in the epidemiology of FHB in FHB-infected areas of SK.

Pathogenicity tests

The isolation of *Fusarium* spp. from heads and roots of cereal crops (above) and roots of noncereal crops grown in rotation with wheat (results from ADF project #98000306) led to the question of whether these isolates were adapted to specific plant parts, or whether they had similar pathogenicity on wheat heads and on roots/crowns.

The objectives of the following experiments were to: (1) determine whether isolates of different *Fusarium* spp. had the same relative pathogenicity on heads and underground plant parts and (2) whether isolates from different sources (i.e. cereal heads and roots and noncereal crops) had the same pathogenicity on heads and roots. This would help determine the impact of leaving infected seed on the ground, the role of infected plant parts in the survival of inoculum from one season to the next and whether this inoculum is a source for head infections. These experiments would also help to assess the potential role that noncereal crops in rotation with cereals might play on the survival of inoculum and development of FHB.

Pathogenicity test #1: Isolates of different *Fusarium* spp. isolated from heads, subcrown internodes and crowns/lower culms were selected from the survey mentioned above. Two cultivars, the hard red spring AC Elsa and the durum wheat AC Avonlea were inoculated at anthesis with a conidial suspension of the *Fusarium* spp. isolates, incubated at high humidity and scored for percent area of heads infected at one, two and three weeks after inoculation. At harvest, percentage FDK and kernel weight were determined. To determine pathogenicity of isolates to seeds/roots/crowns and lower culms, two additional tests were conducted at planting and at the seedling stage (inoculum source placed next to each seed at planting or next to each crown about 3-4 weeks after planting). Seedling emergence, plant survival, discoloration of subcrown internodes and crowns were measured.

Pathogenicity test #2: An experiment was conducted using several *F. graminearum* isolates from different areas of the province and from different plant parts and crops. The purpose was to compare pathogenicity among and between isolates of *F. graminearum* and *F. pseudograminearum* (formerly known as *F. graminearum* Group I), a root pathogen taxonomically related to *F. graminearum*. Wheat plants were inoculated at anthesis with different conidial concentrations to compare FHB and FDK development, and at planting (as

above) to compare pathogenicity on seed and root/crown/lower culms.

Pathogenicity test #3: Pathogenicity tests of *F. avenaceum* isolates from cereal and noncereal sources were also conducted on heads of wheat because *F. avenaceum* is an important FHB pathogen in SK.

Results and Discussion

Results from test #1 showed similar susceptibility of different plant parts to the different *Fusarium* spp. tested. The exceptions were *F. graminearum* isolates which were equally pathogenic to *F. pseudograminearum* and *F. culmorum* on heads but less pathogenic on underground tissue tests. The greater relative pathogenicity of *F. graminearum* on heads than on underground plant parts could be related to stimulatory compounds present in anthers (Strange et al., 1974). Overall, although only a limited number of isolates from each species were tested, there appeared to be a lack of adaptation of isolates to different plant parts. The observation that *Fusarium* spp. isolated from infected heads and subcrown internodes/crowns had similar pathogenicity on heads and underground plant parts, suggests that inoculum from debris from plant parts at or below soil level might be a source of inoculum for infection of heads, and/or that infected heads/kernels might be contributing to root infections (within the same season).

Results from the tests with *F. graminearum*/*F. pseudograminearum* and *F. avenaceum* also showed that differences in pathogenicity among isolates were not associated with the source of the isolates (i.e. whether they came from cereal heads, cereal roots/crowns or from roots of noncereal crops). This led to the conclusion that alternative crops could act as hosts for *Fusarium* spp. which could then infect heads or roots of subsequently grown cereal crops.

The experiments conducted with *F. graminearum* also allowed us to investigate whether root infections by different *F. graminearum* isolates could result in inoculum production, capable of infecting heads, the same season. Perithecia and conidia production on crowns and lower stems of plants that had been infected by all *F. graminearum* isolates at planting (source of inoculum placed next to seed) demonstrated that it was possible for these infected plants to be a source of inoculum for head infection the same season, as well as in future years as previously suggested. This is the first time that inoculum production of *F. graminearum* has been observed in crowns/lower stems of live plants.

This is also the first time that it has been suggested that rotation with alternative crops could affect development of FHB and root rot/seedling blight of wheat in SK. This would be of significance not only in *F. graminearum*-affected areas but also in areas of the province outside the south-east where *F. avenaceum* is the most dominant FHB pathogen.

Results from the *F. graminearum* study formed the basis to recommend that producers should avoid introducing Fusarium inoculum through infected seed into areas of the province not yet affected by FHB. In addition, producers should not blow out the lighter infected seed at harvest and leave it on the soil surface, and should be careful not to spill infected grain in proximity to cereal fields. Recommendations to producers regarding prevention of spread of FHB in SK were made in conjunction with Alberta pathologists. These recommendations are aimed at stopping the spread of FHB in the western Prairies, and it is regarded as a proactive approach to management of FHB.

Continued efforts to stop the spread of FHB in western Canada have also led to the design of a multidisciplinary project, funded by AARI and led by K. Turkington, to gain a better understanding of the spread and development of this disease. Results obtained through this ADF project allowed us to make contributions to the design of the AARI-funded project.

Future work should include the role of seed treatments in preventing the spread of *Fusarium* infections to unaffected areas of the province. The role that crop rotations, especially with legumes, might play in the future development of root/crown infections and Fusarium head blight should also be investigated.

Results from this project are of great benefit to producers and the cereal industry. A better understanding of the epidemiology of FHB and the role that infected seed and root/crown infections of host and nonhost plants might play in the development of FHB contribute greatly to preventing this disease from spreading further in SK.

References cited:

Fernandez, M.R., P. Pearse, G. Holzgang and G. Hughes, 2000. Fusarium head blight in common and durum wheat in Saskatchewan in 1999. Can. Plant Dis. Surv. 80: 57-59.

Fernandez, M.R., P. Pearse, G. Holzgang and G. Hughes, 2001a. Fusarium head blight in common and durum wheat in Saskatchewan in 2000. Can. Plant Dis. Surv. 81: 83-85.

Fernandez, M.R., P. Pearse, G. Holzgang, G. Hughes, and R. Clear, 2001b. Update on Fusarium head blight in Saskatchewan in 1998-2000. Proceedings of Soils and Crops 2001 Workshop. February 2001. Saskatoon pp. 429-434.

Strange, R.N., Majer, J.R. and H. Smith, 1974. The isolation and identification of choline and betaine as the two major components in anthers and wheat germ that stimulate *Fusarium graminearum in vitro*. Physiol. Plant Pathol. 4: 277-290.

Weise, M.V., 1987. Compendium of Wheat Diseases. 2nd edition. APS Press, St. Paul, Minnesota.

Windels, C.E. and C. Holen, 1989. Association of *Bipolaris sorokiniana*, *Fusarium graminearum* Group 2, and *F. culmorum* on spring wheat differing in severity of common root rot. Plant Dis. 73: 953-956.

Research presented at:

- Fernandez, M.R. and G. Holzgang, 1999. Distribution of *Fusarium* spp. causing head blight and root rot in cereals in Saskatchewan in 1998". Pp. 439-445. In: Proceedings of Soils and Crops Workshop '99, Saskatoon, SK.

- Fernandez, M.R., Y. Chen, P. Pearse and G. Holzgang, 2000? "*Fusarium* spp. isolated from heads and roots/crowns of wheat in Saskatchewan and their ability to cause Fusarium head blight". Pp. 481-484. In: Proceedings of Soils and Crops Workshop '00. Saskatoon, SK.

- Talk given on Fusarium head blight and prevention of spread at Crop Production Show, January 2000, Saskatoon.

- M.R. Fernandez, 2001. "Pathogenicity of *Fusarium avenaceum* isolates from cereal and noncereal crops in Saskatchewan". Pp. 120. In: Proceedings of Second Canadian Workshop on Fusarium Head Blight, November 2001, Ottawa, Ont.

- M.R. Fernandez, 2001. "Pathogenicity of *Fusarium avenaceum* isolates from cereal and noncereal crops in Saskatchewan". Poster presented at the Regional meeting of the Canadian Phytopathological Society, in November 2001; abstract published in the Canadian Journal of Plant Pathology.

- M.R. Fernandez, 2001. "Pathogenicity of *F. graminearum* and *F. pseudograminearum* isolates from different sources on common and durum wheat". Pp. 119. In: Proceedings of Second Canadian Workshop on Fusarium Head Blight, November 2001, Ottawa, Ont.

- M.R. Fernandez, 2001. "Pathogenicity of *F. graminearum* and *F. pseudograminearum* isolates from different sources on common and durum wheat". Poster presented at the Regional meeting of the Canadian Phytopathological Society, in November 2001.

- M. R. Fernandez, S. Stolhandske-Dale, R. P. Zentner, and P. Pearse, 2001. "Progress in management of Fusarium head blight in Saskatchewan". Pp. 110-113. In: Proceedings of Second Canadian Workshop on Fusarium Head Blight, November 2001, Ottawa, Ont.

- A summary of projects on FHB being conducted in Manitoba, Saskatchewan and Alberta and progress made to date was presented at the Society of Agronomists' meeting in Lethbridge in June of 2001, on FHB: "Current research in western Canada" by J. Gilbert (Cereal Research Centre), M.R. Fernandez (SPARC), and T. K. Turkington (Lacombe Research Centre).

- Fernandez, M.R., S. Stolhandske-Dale, R. Zentner and P. Pearse, 2001. "The impact of tillage and crop rotation on Fusarium head blight in Saskatchewan". Presentation made to the Canadian Phytopathological Society Regional Meeting. November 2001. Saskatoon, SK.

- Fernandez, M.R. and P. Pearse, 2001. "Prevention of spread of Fusarium head blight in Saskatchewan". Presentation made to the Canadian Phytopathological Society Regional Meeting. November 2001. Saskatoon, SK.

- Gilbert, J., M.R. Fernandez, and T.K. Turkington, 2001. "Fusarium Head Blight: Current Research in Western Canada". Poster presented at the Society of Agronomists' meeting in Lethbridge in July 2001.

- Fernandez, M.R., 2001. "Selling *Fusarium graminearum* infected seed in Saskatchewan". pp. 11-12 in minutes Presentation made to Wheat Cultivar Development Network meeting, June 2001. Lethbridge, AB.

- Fernandez, M.R., 2001. "Fusarium head blight: its causes, symptoms and control". Video-tapes prepared for Precision Ag Services in Carlyle and producers' meeting organized by seed grower in Saltcoats, SK.

Project objectives and results discussed at following meetings:

- Prairie Fusarium Task Force, Brandon, November 24th, 1998
- Wheat program review at SPARC, November 1998.
- Prairie Fusarium Task Force. Winnipeg, February 16th, 1999.
- Wheat Cultivar Development Network, Winnipeg, February 20th, 1999.
- Wheat Cultivar Development Network, Swift Current, June 1999.

- Indian Head Experimental Research Farm Zero-Till Days, July 1999.
- Melfort Research Centre Field Day, July 1999.
- Prairie Fusarium Task Force, Winnipeg, February 20, 1999.
- Wheat Cultivar Development Network, Winnipeg, February 20, 1999.
- Soils and Crops Network meeting, Swift Current, June 1999.
- Wheat Cultivar Development Network, Swift Current, June 22 and 23, 1999.
- Canadian Phytopathological Society Regional Meeting, Saskatoon, November 1999.
- Saskatchewan Advisory Council on Crop Protection, Saskatoon, November 1999.
- Canadian Fusarium Head Blight Workshop, Winnipeg, November 28-30, 1999.
- SPARC Program Review, December 1999.
- Wheat Cultivar Development Network, February 2000, Edmonton.
- Indian Head Experimental Research Farm Zero-Till Days, July 2000.
- Westco Diagnostics School, July 2000, Swift Current.
- Saskatchewan Wheat Pool meeting, July 2000, Swift Current.
- Canadian Phytopathological Society Regional Meeting, November 2000, Saskatoon.
- Saskatchewan Advisory Council on Crop Protection, November 2000, Saskatoon.
- SPARC Program Review, December 2000.
- Wheat Cultivar Development Network meeting, Winnipeg, February 2002.
- Miscellaneous producers' meetings.

- Requested to provide information on this project for miscellaneous media articles, among them: Country Guide, Grain News, and Western Producer.

- Provided results to Seed for Thought on many occasions.

- Several interviews on local radio and TV stations.

Financial support from ADF was acknowledged in all cases.